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Review Article

Extremely High-Frequency Therapy in Oncology

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Abstract

Objective: This article represents a review of the literature, mainly from Russian sources, dealing with the therapeutic application of low-intensity electromagnetic radiation in the millimeter band applied to experimental and clinical oncology.

Method: At the early stage of these studies, efficacy and safety of millimeter electromagnetic radiation (extremely high frequency [EHF]) was proved for various types of malignant tumors. The majority of the further studies demonstrated the high efficacy and safety of millimeter wave radiation in treating patients suffering from both benign and malignant tumors.

Results: Developments led to treatment on skin melanoma, cancer of the ear–nose–throat, bowel and breast cancer, cancer of the uterus, lung, and stomach, solid tumors, as well as lymphoma. The main indications for this therapy are (1) preparation prior to radical treatment; (2) prevention and treatment of side-effects and complications from chemotherapy and radiotherapy; (3) prevention of metastases, relapses, and dissemination of the tumor; (4) treatment of the paraneoplastic syndrome; and (5) palliative therapy of incurable patients.

Conclusions: In spite of the fact that not all mechanisms underlying effects of EHF therapy are known as yet, this therapeutic modality has been shown to have great potential in clinical oncology from studies performed in Eastern Europe and Russia.

Introduction

SINCE THE MIDDLE OF THE 1960s the biological and medical effects of low-intensity electromagnetic radiation (EMR) of the millimeter (MM) spectrum of waveband were studied in various countries including the United States, Canada, France, Germany, and the former Soviet Union.[1–5] As a result of these studies, a new therapeutic method translated from Russian as "extremely high-frequency (EHF) therapy" was designed and approved for clinical application in the countries of the former Soviet Union.[6–8] This article surveys the clinical aspects of this work in oncology. Both authors of this article were involved in this study while in the former Soviet Union.

Millimeter waves come between infrared radiation and centimeter radio waves and include frequencies from 30 GHz to 300 GHz (1 GHz = 10^9 oscillations per second) corresponding to wavelengths from 10 to 1 mm. The power density of this therapy used in medicine varies from 1 to 10 mW/cm^2 or even less, and it does not induce heating effects of an irradiated skin surface.

Therapeutic Generators Applied for Extremely High Frequency (EHF) Therapy

One of the first "therapeutic frequency" 42.19 GHz (wavelength is 7.1 mm) was discovered by the experiments with the cells and mice.[9] Later nonthermal effects of this frequency were confirmed by experiments with yeast.[3] Theoretical supposition about importance of the oxygen absorption lines in the region of 60 GHz was the basis of developing the device with the main frequency 60.12 GHz (wavelength is 4.9 mm). Nevertheless, it is difficult to say whether can some frequencies can be claimed to be universally therapeutic frequencies, nor is it is correct to extrapolate results obtained on the cells and animals for the clinical application.

Special medical generators of MM EMR were developed for EHF therapy including "Jav-I," "Artsakh," "Luch-EHF," and so on. "Jav-I" (4.9 mm): frequency of the coherent radiation is 60.12 ± 0.15 GHz; output power is up to $20 \div 25$ mW; frequency modulation is ± 50–150 MHz. "Jav-I" (5.6 mm): frequency of the coherent radiation is 53.53 ± 0.15 GHz; output power is up to $20 \div 25$ mW; frequency modulation is ± 50–150 MHz. "Artsakh": frequency of the coherent radiation is 60 ± 1 GHz; output power of the coherent radiation is $0.05 \div 5.0$ mW; frequency band of the noise-like radiation is 42–95 GHz; spectral density of the noise radiation is 10^{-18} W/Hz (30 dB/kT$_0$); amplitude modulation is $1 \div 99$ Hz. "Luch-EHF" (7.1 mm): frequency of the coherent radiation is 42.19 ± 0.05 GHz; output power is $0.5 \div 2.0$ mW.

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Application of EHF Therapy in Experimental Oncology

Studies of biological effects caused by electromagnetic radiation have shown that exposure of living organisms to *centimeter-wavelength* radiation before exposing them to a lethal dose of *ionizing radiation* (LD50) reduced their mortality by 50% or more.[10,11] Similar effects were observed when a low-intensity *millimeter-wavelength* radiation was initially applied.[9,12] On the basis of further experiments, it was confirmed that low-intensity MM EMR did not accelerate the tumor growth and provided a hemoprotective effect when applied in combination with chemotherapy or X-ray therapy.[13–17]

EHF Therapy in Clinical Oncology

Clinical research had shown that EHF therapy did not stimulate the growth of either the primary or metastatic tumor,[18–21] and on the contrary, it could suppress its proliferate activity.[15] EHF therapy in oncology was used as a monotherapy for treatment of benign tumors or as a palliative therapy for pain relief and reducing intoxication syndrome. In all other cases, EHF therapy can be applied in combination with surgery, chemotherapy, or X-ray therapy. EHF therapy was used in treatment of gastric polyps and uterine myoma, benign skin tumors and testicular tumors, local fibroadenomatosis and fibroadenoma of mammary gland, malignant skin melanoma, cancer of the stomach or mammary gland, ovarian cancer, carcinoma of the cervix and uterine cancer, cancers of esophagus, lung, bowel, and others.[20–29]

EHF therapy in surgery

In the presurgery period, this EHF therapy (MM-EMR) treated a number of accompanying diseases and thus reduced the risk of surgical intervention. Its application in pre- and postsurgery periods reduced the likelihood of postsurgery complications such as suppurative conditions, hemorrhagic and atonic syndromes, and intensified the healing process of postoperative and postexcision wounds. This treatment stopped the pain syndrome successfully and made it possible to reduce the dose or to abolish the need for narcotic and non-narcotic analgesics. In a number of cases the MM-EMR therapy prevented the development of relapses and metastases.[20,24,25,28–31]

Hemostimulative and hemoprotective effects of EHF therapy

Application of the MM-EMR therapy in a group of patients with initially low content of leukocytes in peripheral blood increased their level to a value making the required chemotherapy possible.[21,30,31] While preserving the antitumor effect of chemotherapy (5-fluorouracil, cyclophosphamide, methotrexate), MM-EMR significantly reduced their toxic effects such as nausea, vomiting, diarrhea, and weight loss, allowing a full-scale treatment without changing the chemotherapy terms or rate. Leukocyte count in the peripheral blood stayed within normal limits.[19–21,32,33] A study of the functional activity of segmented neutrophils by means of the spontaneous rosette test revealed decreasing rosette-forming cells (before treatment: $3.42 \pm 0.21\%$, after treatment: $2.06 \pm 0.26\%$) that pointed to the high activity of these leukocytes, and, likely, explained the mechanism of releasing the toxicity and side-effects observed during chemotherapy.[33] Similar results were obtained when MM-EMR therapy was combined with X-ray therapy. MM-EMR therapy also reduced side-effects of X-ray therapy such as stomatitis, esophagitis, pulmonitis, cystitis, and rectitis, which made it possible to conduct the full-scale course of combined treatment, improving its results and cutting the term from 18.0 ± 4.0 days to 6.5 ± 1.5 days.[25]

Action of MM-EMR therapy on the main symptoms of malignant tumors

In the group of patients suffering from various malignant tumors, MM-EMR therapy could reduce the intensity or completely stop the main pathogenic mechanisms of the neoplastic disease.

Pain syndrome is one of the most important and common symptom of any tumor. The intensity of the pain increased at the latest stages of the disease. After MM-EMR therapy, 94% of patients had analgesic effects varying in degree. The initial analgesic effect took place during the first therapeutic session and a steady analgesic effect occurred after 2–3 sessions of the MM-EMR therapy. After 10–20 sessions, all patients reduced the dose of remedies, or completely stopped the remedies.[14,20,31,33] When patients had any neoplastic process including primary uterine cancer, they had various types of T-cellular immune deficiency manifesting through the reduction of the lymphocytes population, as well as the reduction of the various subpopulations of T-lymphocytes. After the MM-EMR therapy, an increase in T-cells, especially T-helpers and T-suppressors, was observed. Before MM-EMR therapy, the total population of T-lymphocytes was $40.0 \pm 3.1\%$; T-"active" lymphocytes comprised $23.0 \pm 2.1\%$; T-helpers comprised $27.2 \pm 1.8\%$; T-suppressors comprised $13.1 \pm 1.1\%$. After MM-EMR therapy, the total proportion of T-lymphocytes became $47.2 \pm 3.4\%$; T-"active" lymphocytes became $28.0 \pm 1.8\%$; T-helpers became $31.0 \pm 3.6\%$; T-suppressors became $16.0 \pm 2.0\%$. However, the MM-EMR therapy did not change the amount of T-lymphocytes in a control group of healthy volunteers.[15,31,34] Patients with carcinoma of the cervix had noticeably suppressed interferon status, especially at stages II and III of the disease. After MM-EMR therapy, the γ-interferon synthesis increased from 20 to 40 units per milliliter to 95 units per milliliter. In the first stage of disease, the γ-interferon synthesis increased to the normal levels (120 units per milliliter). Among the healthy people, the ability of mononuclear cells in peripheral blood to produce γ-interferon had not been changed by the MM-EMR exposure.[15,30,31,35] Thus, MM-EMR therapy provides immunostimulating effects only in the case when suppression of the immune system took place and did not influence the normal immune status. Leukopenia is one of the usual counterindications for starting both chemotherapy and X-ray therapy. Suppressed leukopoiesis can be activated by the EHF therapy with fixed or individual therapeutic frequencies. Acupoints and reflexogenic zones of the sternum, epigastrium, ethmoidal, occiput, and various other regions were applied. In both methods, the number of leukocytes in the peripheral blood increased from 2500 before treatment to 4000–4500 after treatment. As a result of the MM-EMR therapy, almost all patients could be treated by means of chemotherapy or X-ray.[19,30,31,35]

Preventive application of MM-EMR therapy in oncology

Study of the main mechanisms of tumor pathogenesis allowed application of MM-EMR therapy to reduce the risk of the cancer and prevent various neoplastic diseases from occurring. Tumor tissue secreted the substances that increased blood coagulation and lowered fibrinolytic ability. After MM-EMR therapy, general coagulability potential of the blood, including such factors as fibrinogen, fibrinogen B, prothrombin, clotting time, and aggregability of thrombocytes, decreased by more than 30%.[31] Application of the MM-EMR therapy also restored the ability of mononuclear cells in the peripheral blood to produce γ-interferon and depressed the growth of experimental tumors. This fact may likely explain the therapeutic activity of MM-EMR therapy during treatments of neoplastic diseases of the ovaries or mammary gland, or of lymphoepithelioma and lymphogranulomatosis (Hodgkin's disease), etc.[31]

Application of MM-EMR therapy for terminally ill patients

In applying MM-EMR therapy to terminally ill patients, the following problems must be solved:

1. Improvement of the "quality" of health due to pain relief, and sedative, detoxification, and psychotherapeutic effects;
2. Life prolongation due to improvement of the specific (anticancer) and nonspecific resistance of the patient's body: stimulation of the cells and humoral components of the immunity, treatment and prophylaxis of complications and accompanied diseases;
3. Improvement of the patient's condition to transfer the patient from the "incurable" group to the group where different methods of combined therapy could be applied.

In spite of the lethal outcome and poor prognosis, one should still analyze treatment results in cases of advanced forms of cancer. For instance, in 39 patients suffering from malignant tumors of stage III-IV in various locations, some had undergone palliative surgery, chemotherapy, or radiotherapy. All 39 patients received one or more courses of MM-EMR therapy with individual therapeutic frequencies. This method is named "microwave resonance therapy" or MRT.[36]

The first group ($n = 4$) included patients who died during the first month of observation. They were already in grave condition and suffered from troublesome pain. Examples of these conditions included obturated bowel tumor at the sigmoidostomy; mediastinal tumor with growth into the trachea, bronchi, vessels, and sternum; stage IV stomach carcinoma accompanied by cachexia and ascites; and pancreatic cancer with metastasis to the abdominal viscera and surrounding tissue. After EHF/MRT, patients noticed improvement of their health, relief from the pain syndrome, restoration of their appetite, and improved sleep.

The second group ($n = 10$) included patients who died during the first 6 months of observation. They had cancer of the pancreas, liver, tongue, esophagus, lung, or bowel. As in the previous group, all patients noticed improvement of their health, restoration of their appetite, and improved sleep. Stable relief of pain allowed most of these patients to stop taking the analgesic medicines. There were no signs of cancer destruction. Symptoms such as dyspnea, cough, hemoptysis, choking, difficult swallowing, and others were relieved or even stopped.

The third group ($n = 5$) included patients who survived from 6 to 12 months. It included cancer of the pancreas, papillosphyncter, lung, and ovary. The effect of EHF therapy in this group was the same as in the second group.

The fourth group ($n = 17$) consisted of patients who were still alive when results of the observation were published in 1997 and had cancer of the mammary gland, pancreas, prostate, retroperitoneum, lung, or sigmoid. In this group the pain syndrome was relieved almost completely and there were no signs of cancer progression.[36]

The study presented above resulted in the possibility to make the following conclusions:

1. Positive clinical effects of treatment with the MM-EMR therapy were obtained in 92% of cases; improvement of the "quality of life" could be achieved in 82% of patients;
2. MM-EMR therapy provides relief and can stop the main clinical syndrome accompanying advanced cancer cases; efficacy of the MM-EMR therapy was the same as in the cases of conventional medicines application;
3. After EHF therapy, the cancer may lose features of its "malignancy" such as metastasis and penetration into the surrounding tissues and organs.[36]

MM-EMR Therapy of Malignant Tumors

In the case of malignant tumors, MM-EMR therapy was used in combination with surgery, chemotherapy, and/or X-ray therapy. The exact methods of treatment depended on the character of radical therapy.

Treatment of skin melanoma

MM-EMR therapy was used after the laser surgical removal of the primary tumor. The ethmoidal labyrinth area was exposed to MM-EMR for 30 minutes. The full treatment course included four phases of the therapy consisting of 10–15 sessions (30 minutes each) performed daily. The first phase started immediately after the surgery; the second phase started 1 month after the first phase; the third phase started 3 months after the second phase; the fourth phase started 6 months after the third phase. Relapse and metastases rates reduced independently of position and depth of the invasion area. A 5-year observation period revealed local and remote signs of tumor generalization in the clinical trial group in only 41.1% of the cases, whereas in the control group these complications have been revealed in 71.5% of cases.[21,25,37]

Treatment of ear, nose, and throat cancer

The treatment method described above was used after surgery. In the group receiving MM-EMR therapy, the number of suppurative inflammation cases was reduced by more than half, while the number of patients whose wounds were healed by the first intention increased. Remote results have shown that relapses and metastases had been reduced by more than half (from 29.1% to 12.0% and from 43.7% to 22.0% correspondingly).[25]

Treatment of bowel cancer

In this trial, there were two groups of patients suffering from bowel cancer. In the clinical trial group, patients received both surgery and MM-EMR therapy. In the "control" group, patients received surgical therapy only. In the clinical trial group, wounds healed in 77.7% of the cases by the *first intention*, whereas in the "control" group the wounds had healed by the *first intention* in 30.4% cases only. Relapses of the tumor took place in 23.3% cases in the clinical trial group, whereas in the "control" group it was 50.0%. Metastases took place in 23.3% cases in the clinical trial group, whereas in the "control" group this was 50.0%.[25]

Treatment of breast cancer

Patients who have stages IIb and IIIb of diseases and who were undergoing chemotherapy were treated with the MM-EMR therapy. The course consisted of 14–15 sessions (30 minutes each) performed daily. Three (3) sessions were conducted prior to chemotherapy, two sessions during chemotherapy, and three sessions after chemotherapy. Results of the trial were as follows: chemotherapy when applied in combination with the MM-EMR therapy could be done without toxic side-effects in 95.1% of patients (79.2% in the control group). The number of monocytes and lymphocytes in peripheral blood did not reduce. The quantity of leukocytes was less than 3000 in only 4.5% of cases (18% in the control group) and less than 3500 in only 13.6 % of cases (32% in control group). As a result of the MM-EMR therapy, hemopoietic stability and good tolerance to chemotherapy were achieved and there were no reliable data that indicated bone marrow suppression.[19,20]

Treatment of the patients with uterine cancer (the second stage)

The combined treatment included surgery, with the MM-EMR therapy beginning 3–8 days postsurgery, and a 4–5-week course of radiotherapy beginning 15–16 days postsurgery. Those patients who received MM-EMR therapy had immunity-protective and immunity-modulating effects with preservation of T-helpers lymphocytes both after surgery and the X-ray therapy.[37–39]

Treatment of patients with lymphoma and solid tumor

Patients suffering from lymphoma and solid tumors had received X-ray therapy or combined therapy. To stimulate hematopoiesis, the MM-EMR generator type "Jav-I" was used; 7–10 minutes of EHF exposure was carried out on both the sternum and occiput zones or 30 minutes of EHF exposure was performed to the sternum area only. Additionally, to treat the complications of X-ray therapy or combined treatment, the local application of MM-EMR had been used also. A course of the MM-EMR therapy consisted of 5–15 sessions. After the MM-EMR therapy, 60% of patients noticed improvement of their condition. The objective of changing the parameters of the peripheral blood was already obtained after 6–8 sessions. Local application of the MM-EMR therapy resulted in the release or disappearance of edema and pain after 6–10 sessions. Quick epithelialization of the damaged regions was achieved also.[40]

Thus, the major positive effects of MM-EMR therapy in combined treatment of malignant neoplasm were as follows:

1. The reduction of postsurgical complications;
2. Less expressed side-effects of chemotherapy and X-ray therapy;
3. Hemoprotective and immunity-modulating effects;
4. Reduced number of relapses and metastases.

Indications for MM-EMR Therapy in Oncology

Indications for MM-EMR therapy in a group of oncological patients include:

1. Preparation for radical treatment;
2. Prevention of toxic effects of radiotherapy as well as chemotherapy;
3. Treatment of the complication accompanying or following radical treatment;
4. Combination of EHF therapy with other synergetic methods of treatment applied in oncology including laser therapy, narcotic and non-narcotic analgesic remedies;
5. Treatment of the paraneoplastic syndrome;
6. Palliative EHF therapy of incurable patients;
7. Prevention of metastases, relapses, and dissemination of the tumor.

No direct contraindications of MM-EMR in oncology are known so far. Thus, according to the indications given above, MM-EMR therapy can be recommended for almost any oncological patients.[15,20,25,33]

Discussion

After the series of positive results, some of the authors failed to observe frequency-specific or "resonance" effects of the low-intensity MM-EMR. They declared that results obtained in the Soviet Union have not been reproduced in the laboratories of Europe and North America.[41,42] (One of the explanations of unsuccessful experiments is a standard paradigm of the "precise biological experiment" that does not work in the field of radiofrequency bio-effects[43]). Due to the "pessimistic" conclusion, a majority of the studies had been delayed or even stopped. Nevertheless, extensive studies that were continuing in Russia, Ukraine, Byelorussia, and Baltic countries established this new complementary therapeutic method that can be applied safely and effectively in oncology and other fields of medicine.

It is believed there are enough positive therapeutic results to propose that the application of the MM-EMR therapy is a very powerful complementary tool in treating onclogical and other intractable diseases. Nevertheless, the final conclusion regarding this issue can be made only after appropriate clinical trials take place worldwide. The writers consider that MM-EMR therapy is an inexpensive and noninvasive modality that can be used in the treatment of various diseases, including those whose etiology and pathogenesis are unknown.[8]

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